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V.

ON A PRACTICAL TEST OF THE CONDITION AND COMPOSITION OF NATURAL WATERS.

By Aug. A. Hayes, M.D.

Read, April 14, 1874.

Early in the winter of 1860 I made a verbal communication to the Academy on a mode I had devised for testing the composition and characters of waters at rest or in motion. The illustrations were drawn from the then condition of Mystic Pond, as a source of supply of potable water to the city of Charlestown.

The somewhat novel condition of the pond led me to ask for more time in continuing observations on one source of the water; and, as extensive changes of flow would result from the works to be constructed, it was foreseen that some years must elapse before replies to one or two questions arising could be given.

At that time I stated that the earlier analyses of the water made by myself and others showed that the water at the bottom contained the salts and compounds of sea-water; while a considerable depth of the surface water was adapted, through ordinary purity, as a source of supply, while flowing as a stream.

The saline water at the bottom might be the infiltration from sea-water at a higher level, or possibly an overflow at times of high water, which the dam did not prevent. The source of this water could be determined after the construction of the new works, and subsequent observations and analyses.

It is a frequent remark that ponds and lakes are but enlargements and broadenings of rivers; but there are few cases only of its truthfulness of application. Here we had streams of quite pure water poured into a basin, the bottom of which contained saline water, unfit for domestic purposes.

The success of the public works to be erected for the supply of potable water was deemed by the commissioners and engineer as dependent on a suppression of the contaminating water, and the continuous flow of purer water above it. Further doubt was involved in the solution of the question, arising from the cooling of the surface in the change of seasons to the maximum density, when displacement occurs to the depth where density, due to contamination, equals density arising from cooling.

A moment's consideration of the law of diffusion in liquids at rest will convince any one of the great importance which must be given to the act of flowing, through which it is possible to have a comparatively pure water as a supply, over a body of quiescent water in repose of other composition.

While the subject of source of supply was under consideration, an opportunity existed for exact observations on the volume and position of this mass of contaminated water, more sure than the results of analyses of samples from different depths.

Recurring to my observations on sea-water, I suggested to Mr. C. L. Stevenson, acting as engineer to the Board of Commissioners, that a copper wire, or a strip of silvered copper, weighted so as to descend into the silt, and buoyed at the surface in a vertical position, would take a polarized state. The lower portion would be in the condition of zinc in a compound arc of zinc and copper in acid, being acted on by the sulphur eliminated from a sulphur compound present. In this way the wire, or strip, would write a true statement on itself of the depth of the contaminated water at any point, and define exactly where contamination ceased, by a bright continuous surface above this line, after some days of immersion.

Mr. Stevenson entered with zeal and care on the application of this then novel test, not only demonstrating the condition of gradations of impurity below, but defining by the definite line on the wire, or strip, the exact depth of the purer water above. Many observations were made, resulting in proving the adequacy and value of this mode of testing a mass of water for variation of composition in its parts.

The following year Mr. Stevenson and his assistants extended, agreeably to his promise, the application of the method of observing to other bodies of water, and gave me his original notes of results, both positive and negative: positive in relation to the detection of the smallest portion of contaminated water, and negative when pure natural water alone existed.

Many modifications of the original applications were made, with instructive results observed. Among these results was the considerable conducting power of a hemp or long flax string, which enabled it to replace in part of the length the copper wire or copper-silvered band. He found that the chemical action, when the testing line was used with the whole copper wire, or parts of it, the ferric cyanide of the greenish, blue-colored twine, was decomposed in that part of the water naturally pure, while in the foul water the original color was retained. This change was due to the local production of alkalinity on that part of the twine in the purer water, as a consequence of its polar state, resembling that of a metal wire.

In an extreme case the copper wire, immersed in the silt at the bottom of the water, actually presented scales of sulphide of copper, formed after forty-eight hours' immersion, the temperature 62½° F.

These points illustrate the generality of application in the method, and lead me to notice particularly the chemical action on which it depends, as a mistake has already been published.

When in the decomposition of decaying matters the stage is reached permitting the escape of sulphide of hydrogen, the ordinary tests of lead, silver, and copper compounds detect the sulphur in the ordinary simple way, or the odor of this gas indicates its presence. We have entirely different conditions under view when this test is applied. The most sensitive test for free sulphur fails to detect its presence. A compound of feeble stability, liable to change under the simple change of temperature, or advance in fermentative action, is to be sought for as a deleterious substance. The means used in ordinary cases fail utterly; but the electrical disturbance induced in a copper wire by a simple difference of one part of its length immersed in one medium, while the other part is wet by a slightly differing medium, is sufficient to develop locally, — and locally only, — a change enabling us to obtain evidence of the existence of the deleterious compound, by withdrawing its sulphur, or other like element. The sulphur detected in this way is presumably that which would act under natural conditions offensively or noxiously.

Since the varied application of this method to natural waters has been extended, I have applied it successfully to detect sewage, when mixed with or impregnating drainage water and well water.

The method has been applied to the small volumes of water taken in laboratory analyses, with the same good results. It is only necessary to preserve a separation of the pure from the impure water, through both of which the bright copper wire passes, the temperature of 62° to 75° F. being kept constant. The impure water may be made denser by common salt, so as to take the lowest place; while in testing the method I have made the impure water rest above a pure solution of salt, with like results.

The subject of the contamination of streams and other sources of supply, on which whole populations depend, is becoming of grave importance in this country, and the most minute inquiries in this direction are full of interest.

After the exclusion of high tides from Mystic Pond, analyses prove the continued presence of an undue amount of sea-water constituents in the greatest depths. From obvious sources, dissolved organic compounds are daily added to the water; and, if the purity of this important supply of water is to be preserved, both restrictive measures and careful engineering devices will be required.

The details of observations made on this water would extend this paper to great length. Belonging to the chemical history of waters, they have more of an economical than strictly scientific importance; and this remark applies to the observations made in other bodies of water.